



**PiControl Solutions LLC**

# **Industrial Process Control and Engineering Training Courses**

Ver. 7.8





**Novel & New,  
Voted as  
“The Best”**

## **Industrial Process Control and Engineering Training Courses**

**Practical,  
Designed for  
Control Rooms**

Many new technicians, operators and engineers enter the chemical plant control rooms every year. Responding to the needs of the industry all over the world, PiControl Solutions LLC has developed practical, proven and effective training courses on several industrial process control and engineering topics. PiControl Solutions LLC is a process control, engineering software vendor and industrial training company. PiControl develops and provides software for advanced process control (APC), PID tuning, OPC and training for both industry and colleges.

For more information, please visit [www.PiControlSolutions.Com](http://www.PiControlSolutions.Com) or send an email to [Info@PiControlSolutions.Com](mailto:Info@PiControlSolutions.Com).

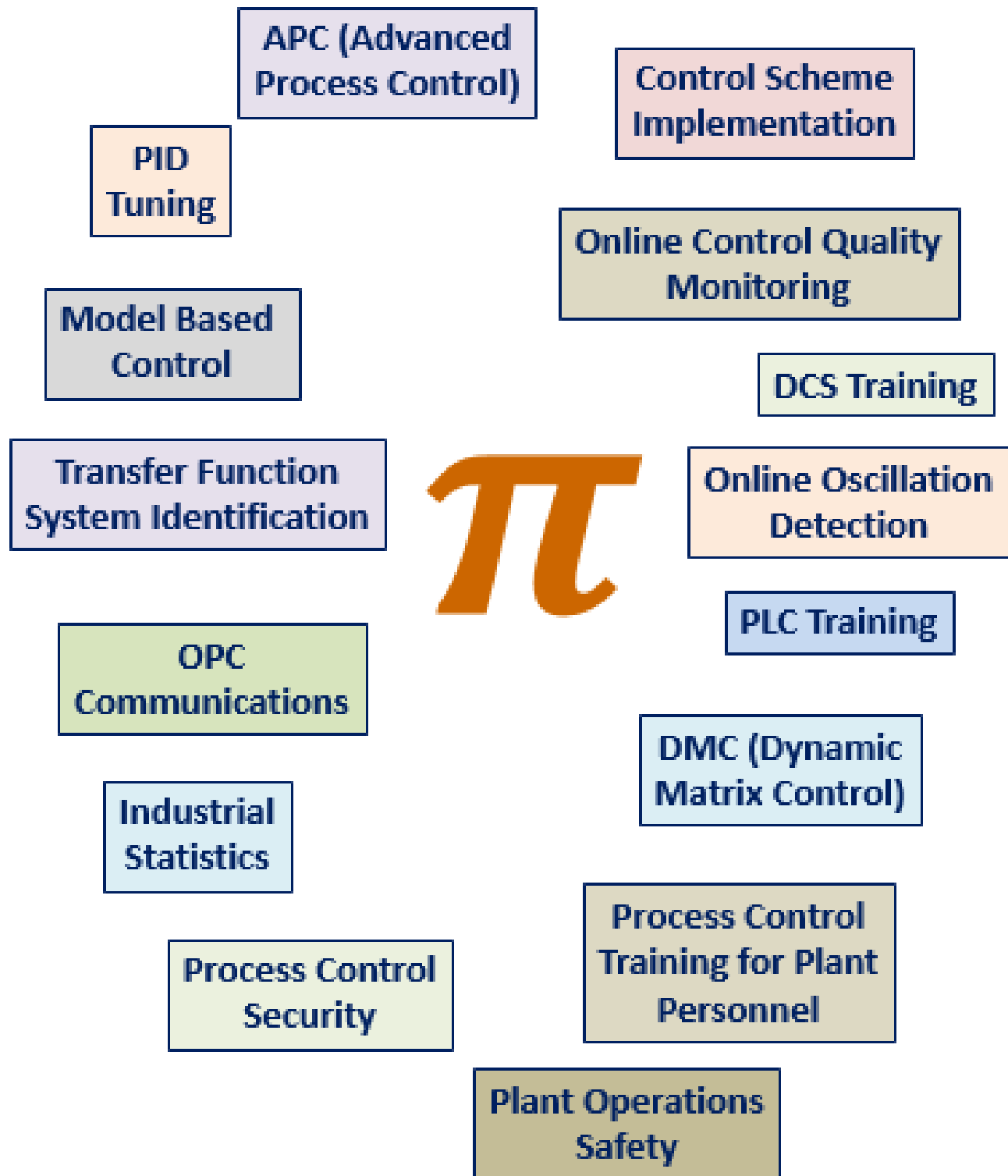
PiControl offers the training courses using three different convenient options—Classroom, Online (using Vimeo and live instructors available for immediate assistance) and Self-Paced (using computer- based training Software modules).

The new courses are very practical; they avoid unnecessary and complicated academic material (not useful in the practical control-room environment) and are aimed at fast learning and immediate application. The courses will benefit operators, technicians, engineers, supervisors, managers - both new and experienced, and also college students.

Unlike other training techniques, PiControl’s new approach is far simpler, more effective and easier to learn and master. The simplicity and ease of use of the training products are because of PiControl’s powerful and user-friendly software user interface, software product design and modern-style training material and approach.

A complete list of all PiControl training courses and their description are shown on the following pages.

# Software, Training, Services



# COURSE LIST

## **Classroom and Online**

**PID100**: PID Tuning Certification and Primary Process Control

**APC200**: Advanced Process Control, PID Tuning and Beyond

**APC275**: Control Scheme Implementation

**MON300**: Control Quality Performance Monitoring and Adaptive Control

**DCS400**: DCS Training for Control Room Operators

**DCS450**: DCS/PLC Advanced Process Control Design and Implementation

**PLC475**: PLC Hardware, Programming and Design

**OPC500**: Industrial OPC Software for Communications and Control- Overview

**OPC515**: Industrial OPC Software for Communications and Control- Hands-On

**SEC600**: Process Control Software, Hardware Security & Cyber Security

**MPC700**: DMC Maintenance

**STA100**: Industrial Statistics, SQC and SPC

**STA200**: Transfer Function Dynamics Identification

**PLT100**: Industrial Safety – Plant Operations and Process Control

## **Self-Paced CBT (Computer-based Training) Software**

**CHE100C**: Basic Chemical Technology and Stoichiometry

**CHE200C**: Material Balances

**CHE300C**: Thermodynamics - Gases, Vapors and Liquid

**CHE400C**: Energy Balances

**CHE500C**: Industrial Process Control - Primary and Advanced Process

## **Course Times and Format Options (Online, Classroom and Self-Paced CBT)**

The classroom courses are conducted at your plant site, training center or at our training facility or in a hotel or some alternate training venue. Local times every day are typically 8:30 AM to 4:30 PM with one-hour lunch break.

PiControl is very flexible and selects training options, venues and locations to best fit the customer need.

Online sessions are based on using Vimeo platform and GoToMeeting for answering student's questions. You can join in from any location anywhere in the world. Broadband internet with at least 1 MBPS speed or higher is required.

Online courses are completely flexible, students can join sessions anytime based on their availability; the sessions can be started, paused, stopped, rewind, or fast-forwarded. During specific time windows every day, students can ask questions to an experienced live instructor for assistance on the theory and software.

Self-Paced CBT (computer-based training) is using software that you install on your computer and then you go through all chapters, sessions and take tests and quizzes. The CBT comprises of several chapters, lab sessions and tests. This is great for people who are currently very busy and are having a difficult time to participate in a classroom or online course with fixed times.

Courses consist of theory (based on classroom sessions or Vimeo/GoToMeeting), software and homework lab and practicals and a final review test. If the student gets 75% or more questions correct, then the student can print a course completion certificate automatically.

## **PID100:** **PID Tuning Certification and Primary Process Control**

<b>Duration:</b>	<b>2 Days Classroom or 15 hours Online</b>
<b>Audience:</b>	<b>DCS Technicians, Plant Operators, Instrument Engineers, Process Engineers and Process Control Engineers.</b>
<b>Prerequisites:</b>	<b>Control room experience as technician, operator or engineer is desirable, but not required.</b>
<b>Course Material:</b>	<b>Software Products used in Course - Pitops, Simcet and Training Slides.</b>

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### **Course Description:**

This course addresses needs of control room operators, DCS technicians, process control engineers, applications engineers and anyone else responsible for PID tuning in the plant. Many new personnel enter the control room these days; there are numerous types of processes and different DCS and PLC systems.

This course starts with the basics of process control, explains the PID equation in the time domain and then trains using three powerful PID tuning, real-time simulation/ optimization and grading software products.

In a remarkably short 2-day time, students learn to optimally tune PIDs and make process changes on distillation columns, reactors, tanks, compressors, flow controllers, heat exchangers using modern real-time simulator software.

The software also has automatic grading capability, so at end of the course, the software generates a report card on the PID tuning skills of each attendee.

This course provides good foundation, skills and knowledge for all DCS/PLC related tag building, control scheme design in a DCS/PLC and the ability to calculate tuning parameters not only for PIDs but other control schemes without the old trial-and-error method but scientifically.

### **Learning Outcomes:**

After completing the course, attendees will be able to tune PIDs in any DCS/PLC, troubleshoot problems, dampen/eliminate oscillations, improve controller performance, all of which helps maximize rates, directly increasing the plant's bottom-line profits.

Through practice on a real-time PID tuning simulator, attendees will gain tremendous confidence in PID tuning on live DCS/PLC's in actual operating plants. This confidence that would otherwise have taken several years on the job now can be achieved in just two days. Attendees will also learn many important and practical concepts about DCS/PLC operations.

### **Day 1:**

Introduction to Industrial Process Control

Process Control Terminology and Definitions

Manipulated Variables, Controlled Variables, Disturbance/Feedforward Variables

Process Control Dynamics and Process Transfer Functions

Open Loop Dynamics

PID Equation in Time Domain and Laplace Domain

PID Examples in Time Domain with Calculation Illustrations  
Process Control Schematics  
Positional and Velocity Forms of PID Equation  
PID Simulations using Pitops and Simcet  
Advanced Forms of PID Algorithms  
Simulating Noise and Process Disturbances  
Filter Action and Filter Time Constant  
Estimating Correct Filter Time Constant in DCS or PLC  
Hands-On Lab (Practical) Sessions Using Real-Time PID Simulator Software

**Day 2:**

Optimal Tuning Theory and Calculations  
Error Criteria for PID Tuning and Quantifying Control Quality  
Typical PID Tuning Parameters for Various Types of Processes  
Optimal Tuning using Pitops Simulator with Disturbances, Noise and Setpoint Changes  
Estimating Process Dynamics from DCS Trends and Operator Knowledge  
Transforming Process Operating Information into Controller Tuning  
DCS Attributes and Features  
Controller Modes  
PV Tracking  
Importance of Derivative Action, When to Use/Not to Use Derivative  
Estimating Derivative Tuning Parameter Scientifically  
Procedures for conducting Step Tests in the Plant  
Continue Hands-On Lab (Practical) Sessions Using Simulator Software  
Cascade Control Basics  
SP/OP Tracking, Bumpless Transfer  
Timed Tests using Training Simulator for Testing

## **APC200:** **Advanced Process Control, PID Tuning and Beyond**

<b>Duration:</b>	<b>3 Days Classroom or 21 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, Advanced Process Control Engineers, Instrument Engineers, Lab Technicians, DCS/PLC Technicians, Managers and Supervisors.</b>
<b>Prerequisites:</b>	<b>PID100, 2-year or 4-year degree in engineering or operations. A few months of plant/ engineering experience is desirable, but not required.</b>
<b>Course Material:</b>	<b>Software Products used in Course - Pitops, Simcet and Training Slides.</b>

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### **Course Description:**

The DCS and PLC have many powerful features that still remain under-utilized. This course shows you how to tune PIDs and build powerful optimizing controllers inside the DCS or PLC. During the course, we use several industrial process control software products - Pitops, Simcet, Process Control CBT and ACSSL.

The course assumes that attendees have completed PID100 course (PID100 is a prerequisite for this APC200 course).

Attendees use real time-series plant data and identify multivariable closed-loop/open-loop dynamics. Then they build various control schemes all inside Pitops software – cascade, constraint override, maximizing and minimizing constraint controllers, selectors, model-based controllers, dead-time compensators and many others.

This course is designed more for engineers but also will offer tremendous value to operators, technicians and supervisors. PiControl software products used in this course are so very easy to use that the course can be comfortably followed by even new and inexperienced technicians. This course also covers advanced functions of PID controllers in more detail.

### **Learning Outcomes:**

At the end of the course, attendees will be able to study a process and its P&IDs and talk to the right people in the plant or control room and then design and build powerful controllers in the DCS/PLC. Attendees will become skilled in PID tuning, feedforward implementation, and parameter specification for all types of controllers in the DCS/PLC.

Further, using scientific process control methods and software products they will be able to calculate tuning and other DCS parameters precisely, thus eliminating guesswork and generating precise, optimized control action.

The course also trains attendees how to be careful while activating and commissioning new control schemes, avoiding mistakes and starting up a control chain in the right sequence.

This course is all you will ever need to use the full potential of the DCS or PLC and build powerful new controllers to stabilize plant operation, push against economic, market, process and equipment constraints. Attendees will also learn when to use traditional advanced control and when to use multivariable model-predictive control, a very practical and useful skill.

**Day 1:**

Process Control Hierarchy  
Advanced Process Control (APC) Options and Strategies  
Need for Automatic Process Control  
Benefits of Process Control  
How to Maximize Throughput and Minimize Utilities using APC  
Feedforward Control Theory and Calculations  
Feedforward Lab Session using Pitops  
Decoupler Strategies  
Advanced Cascade Control  
Cascade Control Lab Session Illustrating an AC-TC Triple Cascade  
Cascade Control Tuning Guidelines  
Constraint Override Selector Control Procedures and Calculations  
How to build correct DCS Configuration for Long Chain Control Schemes  
Startup and Chain Activation Procedures in the DCS  
Practical Rules and Tips for PID and APC Schemes

**Day 2:**

Model-based Control  
Bias Update for Automatic Control  
Closed-Loop Dynamics  
GC-based Online Correction, PV Sample Hold  
Using Rigorous Models for Closed-Loop Advanced Control with PID Integration  
Dead-Time Compensation  
Internal Model-Based Control and Lab Session Internal Model-Based Control  
Identifying Process Dynamics based on Operator Experience and Knowledge  
Identifying Process Dynamics based on DCS Trends and Historical Data  
Continue Lab (Practical) Sessions on System Identification and Tuning Optimization

**Day 3:**

Identification of SISO Closed-Loop Process Transfer Functions  
Multi-Input Closed-Loop Transfer Function Identification  
Identifying Process Dynamics based on analyzing actual Time-Sampled Data  
Lab Session using Pitops to identify first and second order transfer functions using real plant data  
Use Pitops to identify multivariable transfer functions using real plant data in closed-loop mode  
Model-Predictive Control  
When to use PID, Cascade PID, Advanced Regulatory, DMC, RMPCT, Rule-Based Control  
Identifying, Debugging and Troubleshooting PID Tuning and Process Control Problems  
Online PID/APC Control Quality Monitoring and Reporting  
Online Oscillation Detection and Online Control Sluggishness Detection  
PID Control Quality Alerting to Smartphones for Improved Proactive Maintenance

## **APC275:** **Control Scheme Implementation**

<b>Duration:</b>	<b>3 Days Classroom or 21 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, Advanced Process Control Engineers, Instrument Engineers, Lab Technicians, DCS/PLC Technicians, Managers and Supervisors.</b>
<b>Prerequisites:</b>	<b>2-year or 4-year degree in engineering or operations. A few months of plant/ engineering experience is desirable, but not required.</b>
<b>Course Material:</b>	<b>Software Products used in Course - Pitops, Simcet and Training Slides.</b>

### **Course Description:**

This course starts with important basic knowledge about process control nomenclature, primary process control, process dynamics. It then moves into the design of control schemes and implementation inside a DCS or PLC. It covers PID control and transfer functions more concisely compared to PID100 and APC200 courses but spends more time on how to design and implement control schemes inside a DCS or PLC. Knowledge from this course will help any engineer or technician working with any DCS or PLC manufactured from any vendor worldwide. The teaching and concepts are generic and not vendor specific. The course covers how to design and implement both standard and custom function blocks inside any DCS or PLC. This includes batch control, continuous control, sequence control, single PID, Cascade PID, Multiple Cascades and Multiple Slaves, Feedforward Control (lead/lag/dead time/delay), startup/bump-less initialization, PV and SP/OP tracking, Simple Selectors, Constraint Override Control Selectors, Fan-Out Blocks, Ratio Control, Summers/Multipliers/Dividers, Split-Range Control, Safety Shutdown Control Logic, Math Function Blocks, Model-Based Control, Inferential Control, Adaptive Control, Flow Compensation, Linearization, Control Valve Characterization, Totalizers, Ramp and Soak, Switches, Clamps, Anti-Windup Protection, Signal Validation, Safe Design of Control Schemes and Operator Alerts and Advisory.

### **Learning Outcomes:**

At the end of this course, students will have the skills to design and build both continuous and batch control schemes inside any DCS or PLC. Students will have the ability to look at a process flow diagram or P&ID and based on the goals, needs and objectives of the operations or process group, design and implement the appropriate control schemes inside any DCS or PLC. Students will also have the skills to mathematically compute the various tuning parameters and control parameters for the control schemes. The course also teaches good process control habits to avoid making mistakes in the design and avoid plant upsets and shutdowns. Poorly designed control schemes can be dangerous and can cause upsets, shutdowns or even dangerous operating conditions including environmental releases. The course teaches the design of safe control schemes that will take into account operator mistakes, instrument failures and prevent bad things from happening. The course teaches how to provide automation to stabilize the process operation, how to maximize production, minimize cheaper byproducts, minimize utilities, minimize environmental emissions, increase the profit margins and improve key performance indicators.

**Day 1:**

Process control terminology and definition  
Need and Benefits of Process Control  
DCS and PLC Function Blocks  
Batch control, Continuous control and Sequence control  
First Order Transfer Functions  
Zero and Second Order Transfer Functions  
Single PID Control  
Advanced PID functions  
Cascade PID Control  
Multiple Cascades and Multiple Slaves  
Startup / Bump-Less Initialization  
PV and SP/OP tracking  
Anti-Windup Protection

**Day 2:**

How to build correct DCS Configuration for Long Chain  
Control Schemes Startup and Chain Activation Procedure  
Identification of process dynamics using transfer functions  
Feedforward Control (lead/lag/dead time/delay)  
Simple Selectors  
Averaging Control  
Constraint Override Selector Control Procedures and Calculations  
Fan-Out Blocks  
Ratio Control  
Summers/Multipliers/Dividers  
Split-Range Control  
Safety Shutdown and Process Critical Control Logic Design

**Day 3:**

Math Function Blocks  
Inferential and Model-Based Control  
Linearization, Adaptive Control, Gain Scheduling and Control Valve Characterization  
Totalizers  
Ramp and Soak Blocks  
Switches  
Flow Compensation  
DCS Clamps- SP, OP and Operator Entry Validation  
Signal Validation and use in Closed-Loop Control Schemes  
Safe Design of Control Schemes  
Operator Alerts and Advisory.  
Practical Troubleshooting Rules and Tips for PID and APC Schemes  
Model-based Control, Bias Update, Empirical Models and Mass Balance Control

**MON300:****Control Quality Performance Monitoring and Adaptive Control**

<b>Duration:</b>	<b>2 Days Classroom or 20 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, Advanced Process Control Engineers, Instrument Engineers, Lab Technicians, DCS/PLC Technicians, Managers and Supervisors.</b>
<b>Prerequisites:</b>	<b>2-year or 4-year degree in engineering or operations and/or a few months of plant/ engineering experience is desirable, but not required.</b>
<b>Course Material:</b>	<b>Software used: Apromon and Pitops. Also custom training slides.</b>

**Course Description and Objectives:**

Chemical plants can have anywhere from about 50 PIDs in small plants to over 2000 PIDs in large refineries and integrated petrochemical complexes. In addition to simple PIDs, there are cascades, override controllers, model-based controllers and multivariable controllers.

As time goes by, even well-tuned PIDs and other controllers can slowly start to deteriorate. As deterioration progresses, process oscillations can start with small amplitudes and can grow large over time costing the plant significant monetary and/or quality losses. Or conversely, PIDs could become sluggish because of changes in process and operating conditions, once again causing the control quality to deteriorate.

This course covers the technology and application of a control performance monitoring software (Apromon) that identifies poorly controlling PIDs (includes single, cascade, override and complex PIDs). Apromon runs online using OPC and calculates several control criteria and generates control quality reports. Integrated with Apromon is a novel, breakthrough algorithm called TAD (True Amplitude Detection) that accurately isolates oscillating or sluggish controllers. This course shows how to improve and maintain the plant's primary and advanced control system and increase the plant's profits.

This course explains how to identify control problems in an online/real-time manner and take immediate corrective action using online adaptive control. The course also shows how to implement true adaptive control inside the DCS by connecting the control quality monitoring software using OPC technology to the DCS/PLC and by designing special DCS/PLC-resident logic for triggering automatic control action.

**Learning Outcomes:**

At the end of the course, attendees will be skilled in understanding process control quality monitoring criteria and statistics. They will be skilled in the application, installation and use of real-time software products for process control quality monitoring at any plant.

Attendees will also be skilled on the application of online adaptive control technology using the control quality monitoring software and then linking it with closed-loop DCS based-adaptive control schemes. Using the knowledge, attendees on their own can build closed-loop adaptive control schemes at their plant inside the DCS/PLC using OPC connectivity.

Attendees will be able to significantly improve control quality at their plants, move the plant more stably and reliably in the direction of increasing profits with fewer shutdowns and fewer abnormal events. The plant will also see a reduction in the number of alarms and a reduced need for operator intervention.

**Day 1:**

Modern process control in plants  
Process interactions because of mass balance and heat balance integration  
Potential for process cycling and sustained oscillations  
Causes of process oscillations  
Pitops simulations illustrating different oscillation cases  
Pitops simulations illustrating excessive control valve movement  
Pitops simulations illustrating sluggish control  
Definition of various process control quality performance criteria  
Explanation of special new terms – crimp, cheat, vacillation, rope length etc.  
Component breakdown of PID contributions  
Use of process control monitoring software - Apromon-Excel  
Run example cases on Apromon-Excel  
More explanation of process control quality performance monitoring criteria

**Day 2:**

Conduct what-if studies on example using Apromon-Excel  
Adjust and understand oscillation tuning parameters  
Set up online OPC servers to simulate real-plant environment  
Use of Apromon-OPC  
Run example cases on Apromon-OPC  
Implement Apromon-OPC using OPC simulation server  
More explanation of process control quality performance monitoring criteria  
Procedure and tips on implementing Apromon-OPC in a plant environment  
Need for detection of online oscillation in an industrial process  
Need for detection of sluggish control in an industrial process.  
Precise determination of oscillation  
Practical challenges of detecting oscillations reliably  
Understanding of true amplitude detection) algorithm  
Setting up Apromon-OPC and configuring it in online/real-time mode  
Implementing online adaptive control using DCS, Apromon and a OPC server-based computer

## **DCS400:** **DCS Training for Control Room Operators**

<b>Duration:</b>	<b>1 Day Classroom or 6 hours Online</b>
<b>Audience:</b>	<b>Plant Operators, Process Engineers, DCS technicians, Instrument Engineers and Supervisors</b>
<b>Prerequisites:</b>	<b>Some control room exposure is desirable, but not required.</b>
<b>Course Material:</b>	<b>DCS screens and slides</b>

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### **Course Description and Objectives:**

Many new and inexperienced control room operators enter plants every year. This course is aimed at training both new and experienced operators. The course focuses not only on the mechanics of how to use the DCS but also covers many of the intricate details necessary for skilled and high quality operation.

In this course, we teach the operator many important DCS operational details, including DCS tag attributes, parameters and fields, how to start up complex control schemes, the meaning of SP tracking, PV tracking, windup and many other topics. We cover procedures for how to detect control problems and tackle them quickly and effectively. We also cover PID tuning. The operators learn DCS graphics and how to navigate from the various screens. We also teach how to modify and improve DCS graphics using typical configuration methods. The course helps to prevent careless mistakes that could potentially cause shut-downs and encourages safe habits. The operators also learn to fully utilize features like trending, event monitoring, history and other advanced features that can make the operators' time more effective.

### **Learning Outcomes:**

At the end of the course, operators will be skilled on all basic, advanced and practical concepts on DCS operations. They will understand DCS tag attributes and variables. They will know how to activate control schemes correctly, troubleshoot process and control problems and also tune PIDs. They would have learnt tag ranges, tuning parameters, alarm system, alarm limits, rate of change limits, trending in the DCS, event history, logs, reports and security. The course also teaches safety and important good habits recommended for operators. This course is a must for any operator or technician and will be of great value to engineers and supervisors too.

### **Day 1:**

Analog input, output and regulatory tag details, parameters and attributes  
Digital input, output and regulatory tag details, parameters and attributes  
Continuous control programs  
Discrete control programs  
PID equation- how it works  
PID parameters, nonlinear control, gap action, special forms of PID  
Long chains of control tags, cascade chains, chain startup procedure  
Preventing mistakes when entering data into DCS, use of clamp functions  
Event history  
Trending system  
Alarm rationalization, management and enforcement  
Troubleshooting common problems  
Smart messaging and advisory  
Interlocks and Permissives  
Sequence and rule-based controllers  
Safety and reliability in the control room

## **DCS450:** **DCS Control Scheme Design and Implementation**

<b>Duration:</b>	<b>3 Day Classroom or 20 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, DCS Maintenance Technicians, Instrument Engineers</b>
<b>Prerequisites:</b>	<b>Some control room exposure is desirable, but not required.</b>
<b>Course Material:</b>	<b>PowerPoint Slides, DCS screens, Industrial Data, Calculation Procedures and Data Analysis</b>

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### **Course Description and Objectives:**

This course teaches you how to conceive, design and implement process control schemes inside a DCS or even a PLC. There are many DCS and PLC vendors and this course builds skills that are useful for all types and models of any DCS or PLC. Whether you work in a chemical, petrochemical, pharmaceutical, polymer, electric power, paper or really any manufacturing process, this course will teach you the skills to come up with new advanced process control ideas and schemes. The knowledge will also help in the design of controls for safer and smoother plant operation and to run the plant better, smoother and with reduced chance of mistakes, shutdowns and human error. The knowledge will help to maximize production rates, minimize utilities, speed up product grade transitions and improve key performance indicators. In an era of a lot of approaching retirees in industry and the entry of new personnel in the control room, this course is a must for any process control engineer, DCS engineer, PLC engineer or process control technician.

### **Learning Outcomes:**

This course teaches the main components of a DCS and even a PLC. It describes the DCS and PLC architecture. It explains process control network and the concept of L0 – L5 control levels. It explains all DCS and PLC control functions. It teaches standard and custom DCS logic blocks. It covers batch, sequential, continuous and semi-batch control schemes. It teaches how to design and implement control schemes. It shows the safe and correct way of starting up advanced control schemes. It explains how to design and implement PID control, cascade PID control, feedforward control, ratio control, model-based control, adaptive control, constraint override control, production maximizing control, virtual sensors, and closed-loop control using online analyzers. There are numerous industrial examples illustrating process control problems, followed by the design and implementation.

### **Day 1:**

DCS and PLC overview  
DCS and PLC control architecture and control network  
Definition and examples of primary and advanced process control  
Standard function blocks available inside DCS or PLC  
Custom function blocks available inside DCS or PLC  
Building continuous control strategies  
Building discrete control strategies  
MODBUS and OPC interfaces and connectivity to DCS  
Ethernet and coax-based networks  
Process Control Terminal Server  
DCS/PLC remote access and process control security  
Dual redundant and triple redundant control schemes, 2 out of 3 voting  
Programming languages used in DCSs  
Selection of scan rates for different types of tags  
Naming convention tips and recommendations

**Day 2:**

Designing advanced process control schemes inside a DCS or PLC  
Lube Oil Plant APC design and implementation  
Polyethylene APC design and implementation  
Distillation APC design and implementation  
Quarry production maximization design and implementation  
Gas composition mass balance control design and implementation  
Reactor heat balance calculations and yield prediction  
Use of online analyzers and analyzer multiplexing  
Design and implementation of furnace feedforward control  
Design and implementation of ratio control and summer control  
Design and implementation of closed loop cascade control using online analyzers  
Compressor surge control  
Control valve characterization and gain scheduling  
Determining transfer function parameters  
Calculating DCS tuning parameters for APC schemes based on transfer function parameters  
Signal validation, frozen data alarms and spike detection and rejection

**Day 3:**

Median signal PV calculation  
Consideration of safety and abnormal situations  
Design of safe process control schemes  
How to avoid mistakes and design robust control schemes  
HAZOP review procedures  
Safety shutdown control logic and design  
Design and procedure for conducting FAT (factory acceptance tests)  
Safe procedure for activating long chains of control schemes  
eMOC – electronic management of change procedures  
Design and implementation of batch sequence control schemes  
Designing logic for automatic activation and startup of advanced control schemes  
Mixing of batch control and continuous control logic for maximum effectiveness  
Tips and ideas to achieve high onstream factor on DCS and PLC based control schemes  
Protecting control schemes from fault, errors and problems  
Enhanced alarms and user alerts  
Alarm management and event analysis  
Adaptive control design and implementation  
Inferential control design and implementation

## **PLC475:** **PLC Hardware, Programming and Design**

<b>Duration:</b>	<b>5 Day (Classroom) or 24 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, PLC Engineers and Technicians, Instrument Engineers</b>
<b>Prerequisites:</b>	<b>Some control room exposure is desirable, but not required.</b>
<b>Course Material:</b>	<b>PowerPoint Slides, PLC slides, PLC Simulation Software and Industrial Examples</b>

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### **Course Description and Objectives:**

This course teaches you software, hardware and programming skills in using PLCs (programmable logic controllers). The course is designed to build skills in such a manner that upon completion, the student will have the skills needed to work with any PLC. This course like other PiControl courses is not vendor specific. The course starts with basics of PLC, covering both hardware, software and architecture. It teaches ladder logic, function blocks, input/output cards. It explains all basic, standard and custom functions and capabilities of a PLC. With this knowledge, a student will have the skills to design ladder logic, function blocks and safe habits to work in any manufacturing unit. Various real industrial examples are used to illustrate the concepts and with the incorporation and usage of all commonly used PLC functions.

### **Learning Outcomes:**

At the end of this course, students will have strong skills on PLCs. They will be exposed to hardware, software, ladder logic and function blocks. They will have learnt all common PLC blocks and schemes. The course is hands-on and allows students to design and build PLC schemes on their personal computers. With this knowledge, it is possible to design and build PLC logic and control schemes in an industrial environment. The course places significant emphasis on safety, reliability and maintenance for the safe and improved operation of any process. The course covers discrete control, continuous control, adaptive control, safety shutdowns and also the design and implementation of APC inside the PLC.

### **Day 1:**

Programmable Logic Controller (PLC) Overview  
PLC Hardware and Components  
PLC Communication  
Number Systems – Binary, Decimal and Hexadecimal  
PLC Input and Output Cards  
How to read P&IDs and design control schemes  
Relays

### **Day 2:**

Relay Logic Diagrams  
PLC Programming  
Logic Gate Functions  
Motor Starter Logic  
Timers  
Counters  
Setting up PLC software on personal computers  
PLC Lab Hands-On Project 1-3

**Day 3:**

PLC Math Blocks and Functions  
Compare and Jump Instructions  
PLC Lab Hands-On Project 4-6  
Subroutines for Repetitious Calculations and Logic  
Bit Shift Instructions

**Day 4:**

Data Handling Instructions  
Sequence Design and Implementation  
Sequence Instructions  
PLC Lab Hands-On Project 7-10  
Troubleshooting and Maintenance of PLC systems  
PLC Networks in Industry  
Safety Procedures

**Day 5:**

PID and cascade control design inside the PLC  
Developing APC inside the PLC  
Starting up APC schemes  
Safe operating practices and design to avoid making mistakes and process upsets  
Procedures and practices for improved user interface  
Designing PLC schemes for improved GUI and assisting the job of the operator

## **OPC500:** **Basic Industrial OPC Software for Communications & Control**

<b>Duration:</b>	<b>1 Day Classroom or 6 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, Application Engineers, Analyzer Technicians, DCS technicians, Instrument Engineers and Supervisors.</b>
<b>Prerequisites:</b>	<b>Some plant experience and/or a 2-year associates diploma in technical field.</b>
<b>Course Material:</b>	<b>OPC training slides, various OPC software products - OPC Servers, OPC Clients, OPC Explorers and OPC Browsers.</b>

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### **Course Description and Objectives:**

OPC (OLE for Process Control) is now the latest, most modern and powerful communications protocol for the industry. Using OPC, many data transfers can be quickly and effectively facilitated. In addition, many powerful, custom applications can be developed and implemented on an OPC server-based computer connected to the DCS.

This course shows you how to use OPC for many important DCS connected applications, e.g.: bringing online data from gas chromatographs into the DCS, allowing operator entered data on an operator HMI screen to get downloaded into the DCS.

This course also shows you how to connect two independent OPC servers together easily with special software. The course covers how to pull/push data to and from DCS/PLC to host computers. It teaches how to use signal processing and validation for increasing safety and reliability in chemical processes.

The course teaches how to conceive, design and implement new process control, advanced control and communications-related applications using OPC, level-3 computers and DCS/PLC.

### **Learning Outcomes:**

At the end of the course, attendees will clearly understand important concepts about OPC and its use in the industry.

Attendees will be able to connect any OPC server together, transfer data two-way to DCS/PLC, perform custom calculations directly on an OPC server and then talk to the DCS, decipher, troubleshoot and solve OPC problems.

Attendees will understand COM, DCOM, DA, HDA, UA, AE and all commonly used OPC concepts.

Attendees will have the skills and knowledge to develop new applications using OPC, save costs using modern OPC technology and implement new APC and primary control schemes faster and with lower costs.

### **Day 1:**

History and Vision behind OPC technology  
Basic Concepts of OPC  
OPC Specifications  
Benefits of OPC Solutions  
Connection Parameters in OPC Servers  
Configuration of OPC Clients

OPC Redundancy  
OPC DA and HDA  
OPC Client and Server Architecture  
OPC Tunneling Technology  
OPC Alarms and Events  
Windows Security  
OPC options and industry vendors  
XML Overview  
COM and DCOM  
Troubleshooting DCOM Problems  
Systematic Detailed Procedure for Correctly Setting DCOM Configuration  
OPC Diagnostics  
SCADA applications using OPC  
OPC Alarms and Events  
Server-Client-Server (SCS) OPC Applications  
OPC UA (Unified Architecture)  
Overview of connecting OPC clients to OPC servers

## **OPC515:** **Advanced Industrial OPC Software for Communications & Control**

<b>Duration:</b>	<b>1 Days Classroom or 8 hours Online</b>
<b>Audience:</b>	<b>Process Control Engineers, Application Engineers, Analyzer Technicians, DCS technicians, Instrument Engineers and Supervisors.</b>
<b>Prerequisites:</b>	<b>OPC500 course or equivalent OPC software knowledge</b>
<b>Course Material:</b>	<b>OPC training slides, various OPC software products – PiOPC Server, PiBridge, PiLogger, PiConect and PiLims.</b>

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### **Course Description and Objectives:**

This course is an advanced course and continues the OPC500 course. The OPC500 is a must prerequisite for this course.

This course OPC515 is very hands-on. You install various real OPC servers and real OPC clients. You run the OPC servers and OPC clients in full real-time mode. You will witness real-time data transfer and two-ways data communications.

You will get complete real industrial hands-on experience since you are installing and configuring real industrial grade software products.

OPC-related software includes the following:

- PiOPC server (complete industrial grade real-time OPC server with built-in PID control loop simulator, giving a real-plant feel in the training room).
- PiBridge is a dual OPC client capable of connecting to two OPC servers.
- PiLogger is a fast data monitoring, trending and logging OPC client.
- PiConect is an OPC client connecting to MS Excel, collecting real-time data.
- PiLIMS is an OPC client based laboratory information management system.

You will not only see these products during the online session but you will install these products yourself on your own computer for training, learning and hands-on practice. The experience is full industrial grade and the same principles you learn will be applicable in a real industrial plant environment.

### **Learning Outcomes:**

At the end of this course, you will be able to install, configure and activate real industrial grade OPC servers and clients. You will be familiar with both COM and DCOM configuration. You will be configuring both COM and DCOM on your own computer(s).

You will understand how to connect two different devices or OPC clients together. You will install and activate both fast data logging and historizing OPC client and also a LIMS OPC client. You could use the concepts for connecting online analyzers to any DCS/PLC using OPC. You could connect online vibration monitoring sensors to another device. The number of applications and opportunities are diverse and wide-spectrum.

With this knowledge, you will be able to select the right OPC tools (servers and clients) for any industrial application.

**Day 1:**

PiBridge OPC Client Connector

Connecting different OPC servers together

PiConect Human-to-Excel/DCS Interface

Building powerful custom process applications using OPC

Converting any Excel spreadsheet from office/control room and make it online using OPC

Online Analyzer Signals in Chemical Processes

Using validated signals for closed-loop advanced process control

Laboratory Information Management Systems (LIMS)

Using OPC as a modern, new method for implementing LIMS

Overview of PiLIMS Laboratory Data Information Management System

Fast Data Monitoring for Debugging Process Problems and Equipment Shutdowns

OPC Product PiLogger for Fast Data Monitoring

Expert-System Rule-Based Advisory using OPC

Additional Industrial Applications using OPC

Online process optimization using OPC

Fieldbus, Ethernet, OPC comparisons

Practical industrial communications case studies

## **SEC600:** **Process Control Software, Hardware Security and Cyber Security**

**Duration:** 1 Day Classroom or 4 hours Online  
**Audience:** Process Control Engineers, Supervisors, Managers, DCS/PLC Technicians/Operators and Laboratory Technicians.  
**Prerequisites:** None  
**Course Material:** Training slides and hand-outs.

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### **Course Description and Objectives:**

Modern-day process control systems need to be secured and protected against unauthorized personnel, hackers and potentially malicious attackers. Cyber security understanding, needs and a defensive plan is increasingly important these days. Plant and process data must be protected from competitors or contractors having temporary access to the control systems. Viruses, worms etc., can infect and bring-down an entire process control network if the control system is not adequately and appropriately protected. User IDs, access control for new employees, leaving employees, contractors etc. need to be properly implemented and enforced. Control room access, magnetic card access, DCS/PLC access etc., need to be properly enforced in the modern control room and process control environment. This course is a must for process control management and staff in order to protect data, protect the entire control system and ensure safe and reliable operation.

### **Learning Outcomes:**

This course focuses on important process control system security concepts. It helps to staff the control systems team correctly to ensure that control systems security is properly enforced at the plant. The course discusses security forms that can be used to get signatures from various staff members for facilitating securities enforcements. Forms you get from the course can be directly used immediately at the plant. The course provides information to make the plant control system safe and secure.

### **Day 1:**

Industrial process control network architecture  
The concept of L0 – L4 (levels of industrial process control networks)  
Process control system security  
Password, user IDs and handling of shared passwords  
Passwords, user accounts and automatic password expiration  
Protecting non-24-hour manned process control consoles  
Annual logon ID access review and control  
Control room access controls, DCS/PLC configuration access controls  
Engineer, supervisor and operator security  
Preventing unauthorized access  
Protecting proprietary data and intellectual property, attorney reviews  
Sharing control room with different competing technologies  
Satisfying licensor requirements regarding patents and proprietary technology  
Virus patches and updates  
Remote access security and control, remote process control support and monitoring  
Developing securities and control forms for management approval – Break Out session  
Developing the required management approval authority for security and controls  
Protecting proprietary data from offices and control rooms  
Developing teams to manage process control systems and audits  
How to conduct formal process control audits to ensure control system reliability

## **MPC700: DMC Maintenance**

**Duration:** 2 Days Classroom 18 hours Online  
**Audience:** Process Control Engineers, DCS Technicians and Supervisors.  
**Prerequisites:** Knowledge of primary process control, PIDs etc. and preferably a few months of plant experience especially on a DCS.  
**Course Material:** Training slides and DMC software.

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### **Course Description and Objectives:**

This course trains on the use of DMC (dynamic matrix control) software. It starts from the fundamentals: the history behind DMC, the need for DMC, how DMC is superior when used right and where other control methodologies could be more appropriate. The course covers how to conduct step tests and identify DMC models, designing and building the DMC controller, startup and commissioning. The course also covers DMC maintenance, how to modify and improve DMC models after years of operation or after significant process changes. It covers automated step testing, PRBS and other new techniques.

### **Learning Outcomes:**

At the end of the course, attendees will be equipped with the skills to design, maintain and troubleshoot DMC controllers. They will be able to use the modern 3G closed-loop dynamics identification technology to improve DMI models using Pitops-TFI. They will have the skills to observe plant trends and troubleshoot the DMC controller and discuss with operations and control engineers on how to improve the control.

### **Day 1:**

History of DMC, benefits of DMC, areas where DMC is vastly superior  
Applications where DMC should not be used, alternate control methodologies  
DMC software product overview, different modules and building procedure  
DMC algorithm overview – how it works – prediction, correction and time shift  
Conducting step tests, rules for conducting good tests  
Getting DMI models, techniques and procedures for getting good models  
Eliminating models and relationships that can harm control quality  
Building the DMC controller, running in prediction mode

### **Day 2:**

LP algorithm, LP versus SQP, determining correct LP costs to ensure stable LP solution  
Using DMC to locally optimize the process operations  
Practical examples to illustrate DMC design and optimization  
DMC LP optimizer and Turbo-Max online nonlinear optimizer  
DMC controller maintenance  
Using Pitops TFI to improve DMC models using short-duration closed-loop data  
Effect of small gain models, how to reduce/eliminate cycling and instability  
Prediction error feedforward  
Adaptive gains, nonlinear control challenges and how to overcome them  
DMC Web-server and remote access  
Online maintenance examples to improve DMC operation and monetary benefits  
Advanced DMC tips and procedures

## **STA100:** **Industrial Statistics, SQC AND SPC**

<b>Duration:</b>	<b>6 hours Online Only</b>
<b>Audience:</b>	<b>Process Engineers, Research Engineers, Laboratory Personnel, Analyzer Technicians, Instrument Engineers and Supervisors.</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>Training slides and various statistical software products.</b>

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### **Course Description and Objectives:**

Train engineers, technicians and supervisors on the latest statistical tools, methods and practices. Apply statistical methods to analyze process and plant data. Understand statistical quality control, statistical process control, six sigma and related topics. Understand customer quality needs and implement monitoring and statistical methods to improve control.

### **Learning Outcomes:**

At the end of the course, attendees will understand all practical concepts on statistics. They will be able to apply statistical principles and theory to their practical plant data and control problems. They will be able to use modern statistical tools and apply them to actual plant data. The knowledge will help directly to improve statistical control at the plant and achieve more customer satisfaction.

### **Day 1: (8:30 AM to 4:30 PM)**

Analyze, interpret and present data in a meaningful way and Descriptive statistics  
Histograms, Pareto charts, Scatter Plots, Confidence Intervals, T-tests and F-tests.  
Sampling strategies, transformations, power and sample size calculations  
Analysis of variance (ANOVA), Non-parametric tests and Regression  
Determine when a real problem exists and if process improvements, changes are required  
X and mR, Xbar and R, c, u, np, p, CUSUM and EWMA charts  
Capability indices Cp, Cpk, Pp and Ppk, Time series plots, Trend analysis and Decomposition

### **Day 2: (8:30 AM to 4:30 PM)**

Moving averages and other smoothing methods  
Statistical hypothesis tests - equivalence testing  
One-way analysis of variance and confidence intervals showing their application to validation  
Problem definition, selecting responses and factors  
Scoping studies, Screening designs, Taguchi methods, fractional and full factorial designs  
Response surface methodology (RSM)  
Product design, semantic scales, questionnaire design  
Factor analysis and Principal components analysis (PCA)

### **Day 3: (8:30 AM to 4:30 PM)**

Gauge repeatability and reproducibility studies  
Gauge linearity and bias studies and attribute agreement analysis  
Estimate relationships between independent variables and dependent variables  
Understand and explain relationships among variables and use them to predict actual responses  
Understand product and system lifetimes. Product reliability and failure modes  
Manufacturer's methods to inform warranty periods  
First-time failure rates, terminal failure rates, non-repairable devices, repairable systems, test plans and the Weibull distribution.

## **STA200:** **Transfer Function Dynamics Identification**

<b>Duration:</b>	<b>4 hours Online Only</b>
<b>Audience:</b>	<b>Process Control Engineers, Process Engineers, Research Engineers, Laboratory Personnel, Instrument Engineers and Supervisors.</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>Training slides and Pitops-TFI software product.</b>

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### **Course Description and Objectives:**

Identification of transfer functions using industrial process data is both an art and a science. Industrial data comprises of fast noise, drifts and disturbances; these result in special challenges while trying to accurately estimate the transfer function parameters. We use the most modern, advanced and sophisticated 3G dynamics identification technology (Geometric, Gradient and Gravity components) to isolate fast and slow disturbances to accurately determining the true transfer function. The technique used works remarkably well even for multivariable inputs using closed-loop data. Another unique feature is the successful transfer function identification with relatively short-duration data (where other techniques are commonly unsuccessful). The new method used in the course is far simpler and more powerful than other currently practiced methods. It can be easily learnt and applied by new personnel without advanced educational degrees or prior experience.

### **Learning Outcomes:**

At the end of the course, attendees will be able to identify multivariable (multi-input) transfer function parameters using closed-loop data, open-loop data or a mixture of both. Attendees will learn skills to help isolate disturbances and identify the true transfer functions. The skills will be useful in all fields dealing with transfer functions – chemical, mechanical, electrical and industrial engineering, all branches of science (particularly chemistry), medical fields, population studies, statistics and related fields. The modern techniques are both revolutionary and novel; they produce successful results even with challenging data sets comprising of significant levels of complex, unknown and unmeasured disturbances.

### **Day 1:**

Transfer function definition  
Fast and slow processes  
Different methods of characterizing process dynamics  
Characterizing high order transfer function models  
Step response coefficient models  
ARMA models  
Pros and cons of various dynamic models  
Open loop step tests, closed-loop tests, gradual changes in input

### **Day 2:**

3G disturbance rejection technology- Geometric, Gradient and Gravity options Isolating noise from process data  
Dead time estimation tips  
Model prediction and correction procedures  
Industrial examples using real plant/process data  
Identification examples using many real and simulated conditions  
Zooming on the real transfer function in cases of multiple solutions  
Practical tips for successful closed-loop transfer function identification

## **PLT100:** **Industrial Safety–Plant Operations and Process Control**

**Duration:** 1 Day Classroom or 8 hours Online  
**Audience:** Operators, Technicians, Engineers, Supervisors and Managers.  
**Prerequisites:** None  
**Course Material:** Training slides and hand-outs.

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### **Course Description and Objectives:**

Despite advances and improvements on safety in modern-day plant operation, injuries, illnesses and fatalities on-the-job still happen. The course covers most common areas of safety related to plant operation, startup, commissioning and maintenance. A unique aspect of the course is that it also discusses how process control schemes and strategies may be used to increase operational safety. The course also aims at increasing safety awareness and reducing both on-the-job and off-the-job safety-related incidences.

### **Learning Outcomes:**

After completion of the course, attendees will be familiar with important safety concepts relevant to chemical plants. They will be more aware of hazards and will be more cognizant of imminent dangers. Course attendees are likely to operate and work safer than ever before and contribute to improved company safety records. This course is a must for operators, technicians, engineers and managers.

### **Day 1: (8:30 AM to 4:30 PM)**

Safety in perspective, causes of accidents, psychological and human nature  
What employees, management and personnel can do to mitigate accidents and improve safety  
Accident examples and what could have been done to avoid them  
Industrial safety, working safely with chemicals, safe handling of pressurized gases  
Welding safety  
Electrical and lighting safety Material handling  
Machine shop safety Powered hand operated tools  
Back safety, correct lifting technique  
Asbestos awareness, ammonia, H<sub>2</sub>S, and other hazards Asphyxiation dangers  
Blood-borne pathogens  
Fire safety, different types of fires and fire extinguishers Hazard communications  
Hazardous materials transportation  
Lock-out and Tag-out procedures  
Material safety data sheets  
Office ergonomics  
Personal protective equipment  
Scaffolds  
Slips, trips and falls, fall protection  
Forklifts  
DOT training  
Using DCS/PLC control schemes and advisories for increased safety  
Online analyzer – GCs and other analyzers and how to use them in process control strategies  
Incorporating safety in design of process control strategies and online closed-loop advisories

## **CHE100C:** **Basic Chemical Technology and Stoichiometry**

<b>Duration:</b>	<b>Self-Paced Training Software</b>
<b>Audience:</b>	<b>Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors.</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>CBT (computer-based training) software</b>

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### **Course Description and Objectives:**

This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and principles of basic chemical technology and stoichiometry.

### **Learning Outcomes:**

Master the concepts of basic chemical technology and stoichiometry. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

### **Course Chapters:**

1. Basic Information and Stoichiometry
2. Units, Dimensions, and Conversions
3. Dimensional Homogeneity and Analysis
4. Dimensionless Groups and Analysis
5. Pressure and Temperature
6. Process and Process Units
7. Mass, Density, Volume and Mole
8. Chemical Equations and Stoichiometry

## **CHE200C:** **Material Balances**

<b>Duration:</b>	<b>Self-Paced Training Software</b>
<b>Audience:</b>	<b>Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>CBT (computer-based training) software</b>

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### **Course Description and Objectives:**

This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and the principles of material balances.

### **Learning Outcomes:**

Master the concepts of material balances which are so critical and useful in the plant operation and process design. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

### **Course Chapters:**

1. General Balance Equation
2. Material Balances without Chemical Reaction
  - a. Distillation
  - b. Mixing/Settling
  - c. Drying/Evaporation
  - d. Absorption
  - e. Extraction
  - f. Crystallization
  - g. Adsorption
3. Material Balances without Chemical Reaction - With Recycle, Bypass, Purge
  - a. Distillation
  - b. Drying/Evaporation
  - c. Combination of Units
4. Material Balances with Chemical Reaction
  - a. Recycle
  - b. Purge
  - c. Multiple Equipment
  - d. Combustion

**CHE300C:**  
**Thermodynamics - Gases, Vapors and Liquids**

<b>Duration:</b>	<b>Self-Paced Training Software</b>
<b>Audience:</b>	<b>Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>CBT (computer-based training) software</b>

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**Course Description and Objectives:**

This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and principles of practical industrial thermodynamics.

**Learning Outcomes:**

Master the concepts on thermodynamics. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

**Course Chapters:**

1. Pure Components
  - a. PVT Relations
  - b. Ideal Gases
  - c. Real Gases
  - d. Vapor Pressure
2. Mixtures
  - a. Ideal Gases
  - b. Real Gases
3. Ideal Solutions
  - a. Phase Rule
  - b.  $t / P$ - $x$ - $y$  Diagrams
  - c. Raoult's & Henry's Laws
4. Humidity And Saturation
  - a. Air + Water System
  - b. Air + Solvent System

## **CHE400C:** **Energy Balances**

<b>Duration:</b>	<b>Self-Paced Training Software</b>
<b>Audience:</b>	<b>Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>CBT (computer-based training) software</b>

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### **Course Description and Objectives:**

This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and principles of energy balances.

### **Learning Outcomes:**

Master the concepts on energy balances which are so critical and useful in process design and plant operation. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

### **Course Chapters:**

1. Heat Effects
  - a. Without Phase Change
  - b. With Phase Change
  - c. With Water & Steam
2. General Energy Balance Equation
  - a. First Law of Thermodynamics
  - b. Application To Processes
  - c. Mechanical Energy Balance
3. Energy Balances With Reaction
  - a. Enthalpy of Formation
  - b. Enthalpy of Reaction
  - c. Enthalpy of Combustion
  - d. Adiabatic Flame Temperature
  - e. Application To Processes
4. Enthalpy of Solution & Mixing
5. Application To Processes
6. Heating Values of Fossil Fuels
  - a. Coal
  - b. Petroleum
  - c. Gas

**CHE500C:**  
**Industrial Process Control -Primary and Advanced Process Control (APC)**

<b>Duration:</b>	<b>Self-Paced Training Software</b>
<b>Audience:</b>	<b>Process Control Engineers, DCS/ PLC Technicians, Operators, Process Engineers, Contact Engineers, Supervisors, Managers, Project Engineers</b>
<b>Prerequisites:</b>	<b>None</b>
<b>Course Material:</b>	<b>CBT (computer-based training) software</b>

**Course Description and Objectives:**

Process control courses in universities are still too academic and the training is not adequate for the industrial control room environment. This course covers the practical industrial aspects of process control like no other textbook or course available currently. What would take a typical engineer or technician numerous years of hands-on experience in the control room now can be mastered by this modern, powerful CBT in just an amazing span of a few hours. This course will benefit both new and experienced engineers, operators, supervisors, managers, professors and students. It covers modern industrial process control theory - both primary process control and advanced process control (APC) and can be used by both technicians and engineers without need for advanced math and other background or skills.

**Learning Outcomes:**

After completion of the course, the students will understand the concept of DCS and PLC architectures and networks. They will understand process control schematics, basic process control theory, system identification, step testing, dynamics characterization. The course teaches PID control, cascade control, feedforward control, constraint control, override control, model-based control, model-predictive control, and other forms of APC (Advanced Process Control). The course teaches how to design and implement primary and advanced process control schemes inside a DCS or a PLC. It teaches skills on when to use PID and APC and when to use a DMC (dynamic matrix control) or other forms of multivariable model-predictive control. It teaches how to design and implement closed-loop controllers in the practical control room environment. It also teaches concepts typically not covered in universities and concepts that take a long time to learn on one's own on-the-job time and effort. The course helps to convert both new and experienced personnel into skilled process control experts in a remarkably short time.

**Course Chapters:**

**Part I: Primary Process Control (Study Time » 25 Hrs.)**

- 1) Overview of Modern Industrial Process Control
  - a. Overview
  - b. Need For Process Control
  - c. Distributed Control System
  - d. Choice of DCS or PLC
  - e. Laboratory Information Management System (LIMS)
  - f. Safety Interlocks and Shutdowns
  - g. Permissives
- 2) Process Control Variable Definitions
  - a. Controlled Variables (CV)
  - b. Manipulated Variables (MV)

- c. Process Variable (PV)
  - d. Setpoint (SP)
  - e. Process Dynamics
  - f. Transfer Function
  - g. Transfer Function Parameters
  - h. Linear and Nonlinear Processes
  - i. Identifying Process Dynamics
  - j. Dynamics Identification Procedure
  - k. Dynamics Identification With Multiple Inputs
  - l. Rules For Conducting Pulse Tests
- 3) Primary Control and The PID Algorithm
- a. Manual Control
  - b. Automatic Control
  - c. The PID Algorithm
  - d. Sign of the three terms
  - e. Offset
  - f. Primary Control
- 4) PID Algorithm - Additional Options and Parameters
- a. Process Noise
  - b. Filter Time Constant
  - c. Direction of Control Action
  - d. Direct and Reverse Action
  - e. Other Forms of The PID Algorithm
  - f. Nonlinear PID
  - g. Output Sponge PID
  - h. Split Range PID
  - i. PID Faceplate
  - j. PID Detailed Screens
- 5) Cascade PID Algorithm
- a. Level-To-Flow Double Cascade
  - b. Temperature-To-Temperature Double Cascade
  - c. TC-FC Double Cascade
  - d. AC-TC-FC Triple Cascade
  - e. AC-TC-QC-FC Quadruple Cascade
- 6) Override Control Strategies
- a. Dual Level Control
  - b. Dual Temperature Control
  - c. Low Level Override Constraint Control
  - d. Distillation Reflux Flow Override
  - e. Compressor Override Controls
  - f. High and Low Override Constraint Control
  - g. Maximization of Production Rates
  - h. Need For Constraint Override Control Strategies

- 7) PID Modes and PID Activation Procedure
  - a. PID Controller Modes
  - b. Summary of Different PID Modes and States
  - c. How To Change PID State
  - d. Ranges of A PID Controller
  - e. Setpoint Tracking and Output Initialization
  - f. The "Track" Flag
  - g. Bumpless Transfer
  - h. Cascade Chain Activation Sequence
  - i. Chain Activation Sequence For A Constraint Override Loop
  - j. PV Tracking
  - k. How To Enable PV Tracking
  - l. Benefits of PV Tracking
  - m. When To Use PV Tracking
  - n. PV Tracking In Case of Master PIDs
- 8) PID Tuning Procedures and Control Quality
  - a. Open-Loop and Closed-Loop Mode
  - b. Engineering Units of PID Tuning Parameters
  - c. PID Tuning Procedures
  - d. Effect of Range Change on PID Tuning Parameters
  - e. Advanced Control PID Control
  - f. PID Tuning and Control Quality
  - g. Comparison of The Criteria

9) Process Control Schematics

**Part II: Advanced Process Control (Study Time » 30 Hrs.)**

- 10) Disturbances, Feedforwards and Decouplers
  - a. Disturbance
  - b. Feedforward Control
  - c. Feedforward and Feedback Control Examples
  - d. Feedforward Strategy Implementation In DCS or PLC
  - e. LEAD and LAG Action
  - f. Final Steady State Value From Feedforward
  - g. Cases where Feedforward Control may not be effective
  - h. Distillation Column Feedforward
- 11) Process Signal Filtering and Control Valve Checkout
  - a. Signal Noise
  - b. Effect of excessive noise on control quality
  - c. Filter Constant
  - d. When To Use Filtering
  - e. Selecting Filter Constant
  - f. Optimal Filtering
  - g. Adding Filtering During PID Tuning
  - h. Impact of Noise Band on Open-Loop Test Procedure
  - i. Identifying Valve Problems

- j. Effect of Noise on PID Control Action
- 12) Dead Time Compensation and Model-Based Control
- a. Dead Time in Control Loops
  - b. Effect of Dead Time On Control Quality
  - c. When Dead Time Is Really Harmful In A Control Loop
  - d. Methods to combat dead time
  - e. Dead Time Compensation Implementation in DCS or PLC
  - f. Model-Based Control
  - g. Pure Transfer Function-Based Models
  - h. Rigorous Predictive Models
  - i. Steps In Implementing A Rigorous Model-Based Control Scheme
- 13) Control Schemes Using Discrete Signals
- a. Continuous Signals
  - b. Discrete Signals
  - c. PV Sample Delay
  - d. Discrete Signals
  - e. Distillation Control With PV Sample Delay
  - f. Distillation Cascade Control With PV Sample Delay
  - g. Analyzer Multiplexing
  - h. Inferential Model-Based Control
  - i. Spike Rejection ii) Frozen Value Check
  - j. PID Scan Time
- 14) Model Predictive Control and Rule-Based Control
- a. Types of Process Control Strategies
  - b. Characterizing Process Dynamics In MPC
  - c. Control Matrix
  - d. MPC Algorithm
  - e. Feedback Correction
  - f. Rate of Change
  - g. Multivariable MPC System
  - h. Priority of Controlled Variables
  - i. Local Optimization
  - j. When To Use MPC and When To Use TAC
  - k. When To Use MPC and When To Use TAC
  - l. Analyzing the criteria to select TAC or MPC
  - m. Benefits Due To Advanced Control
  - n. Pros and Cons of MPC Versus TAC
  - o. Operating Zones
  - p. Rule-Based Control and Fuzzy Control
  - q. Types of Advanced Control Tools
- 15) Handling Nonlinearities
- a. Linearity
  - b. Valve-To-Flow Nonlinearity
  - c. Gain Scheduling
  - d. Valve Characterization

- e. Constraint Control
- f. Reflux-To-Product Impurity Nonlinearity
- g. Average Temperature Control

### **Part III: Lab Session (Study Time » 20 Hrs.)**

#### **16) Lab Sessions (Practical Exercises)**

The various simulation exercises will be conducted with PITOPS<sup>®</sup> industrial process control software. This software accompanies this training module and can be used in a variety of ways.

PITOPS<sup>™</sup> software consists of two modules - PITOPS-PID and PITOPS-TFI.

PID stands for PID Control Tuning and Design.

TFI stands for Transfer Function Identification.

PID module simulates PID controllers, cascade PIDs, feedforward loops and Dead Time Compensator. Various other features are provided for primary and advanced control tuning and design. TFI module identifies transfer functions using time-series plant data. The following nine lab sessions will be conducted using the PITOPS-PID module and tenth session using PITOPS-TFI module.

1. Configure a transfer function and study open-loop response.
2. Configure a PID loop, simulate a setpoint change, and tune the PID.
3. Add random noise to the previous simulation.
4. Configure external disturbances.
5. Tune a Temperature Control PID (TC).
6. Tune a Level Control PID (LC).
7. Tune a cascade PID.
8. Configure Disturbance and Feedforward transfer function.
9. Configure a Model-based Dead-time compensator.
10. Identify a transfer function using simulated plant data.
11. Guidelines and Recommendations